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(54) FRICTION WELDING METHOD FOR DIFFERENT MATERIAL

(57)Abstract:

PURPOSE: To obtain a joint material of high reliability by making the diameter of a material having larger coefficient of thermal expansion larger, providing the conical recessed part at the tip of the large diameter side and the same shaped projection part at the tip of the small diameter side and executing friction welding.

CONSTITUTION: Truncated-cone-shaped joining faces are composed by respectively working the truncated-cone-shaped recessed and projected parts at the tips of members to be joined, generating frictional heat in those parts and executing upset pressurizing in the axial direction. The truncated-cone-shaped

recessed part larger than that of the other member is provided on the member of larger coefficient of thermal expansion of both members. In these ways, compressive stress is loaded on the slant face of the joining face in cooling process after friction welding and joining strength is increased. Further, since joining face wider than a conventional flat joint face is provided, the joining strength is increased in proportion to the increment of area.



[Claim(s)]

[Claim 1] The friction welding method of the contaminant characterized by facing carrying out friction welding of the contaminant from which material properties, such as a coefficient of thermal expansion and high temperature strength, differ, making the diameter of an ingredient with a big coefficient of thermal expansion larger than the diameter of other ingredients joined to this, and establishing the depression of a cone form at the tip by the side of a major diameter, preparing the heights of the same configuration as the above-mentioned depression at the tip by the side of a minor diameter, and carrying out friction welding of both the ingredients.

[Claim 2] The friction welding method of the contaminant according to claim 1 characterized by coming to prepare a slot in the slant face of the depression of the cone form at the tip by the side of a major diameter.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to this method of being suitable for manufacture of the transition joint components applied to piping of the fuel tank carried in various kinds of transition joint components, especially a scientific satellite, etc. about the friction welding method of a contaminant.

[0002]

[Description of the Prior Art] Conventionally, as shown in drawing 6, the friction welding of a tubing-like transition joint has held the contaminant (A, B) of the diameter of said from which a material property differs by the chuck of pressure-welding equipment, heated cylindrical or the part which should be made to rotate one side and should be joined with friction energy, carried out upsetting pressurization with the welding pressure (P) of shaft orientations, and was performed. Therefore, A material and B material of the diameter of said are joined, and the shaft-orientations cross section after junction presents the situation that the amount and configuration of weld flash differed from each other according to each material strength, as shown in drawing 7. In such a conventional joint, generating of the residual stress produced according to the difference in the material property of both members (A, B) and the fall of the joint reinforcement accompanying this pose a problem most.

[0003] That is, if a coefficient of thermal expansion differs from high temperature strength sharply in many cases and friction welding is simply performed by the conventional approach in such a case, in both junction interface, residual stress (shearing stress) ( $\tau$ ) as shown in drawing 8 will generate especially a contaminant.

Drawing 8 sets the zero of an axis of coordinates in the axial center of a junction interface, and it is what showed distribution of the shearing stress ( $\tau$ ) to radial [ of a member ], shearing stress ( $\tau$ ) increases in secondary function on the surface of a member, and even when this does not have crack generating and crack generating after a pressure welding, it becomes causes, such as a fall of joint reinforcement.

[0004]

[Problem(s) to be Solved by the Invention] As clarified for the preceding clause, when friction welding was performed for the contaminant from which a material property differs in the condition that a plane of composition is flat, with the diameter of said, the high stress which is going to destroy a junction interface occurred, it became loam Lycium chinense about crack generating or the fall of joint reinforcement, and there was a fault that reliable joint material was not obtained.

[0005] In view of the above-mentioned technical level, this invention tends to cancel the fault of a conventional method and tends to offer the friction welding method of a contaminant for the ability to obtain reliable joint material.

[0006]

[Means for Solving the Problem] This invention is the friction welding method of the contaminant characterized by facing carrying out friction welding of the contaminant from which material properties, such as (1) coefficient of thermal expansion and high temperature strength, differ, making the diameter of an ingredient with a big coefficient of thermal expansion larger than the diameter of other ingredients joined to this, and establishing the depression of a cone form at the tip by the side of a major diameter, preparing the heights of the same configuration as the above-mentioned depression at the tip by the side of a minor diameter, and carrying out friction welding of both the ingredients.

[0007].(2) It is the friction welding method of the contaminant of the above-mentioned (1) publication characterized by coming to prepare a slot in the slant face of the depression of the cone form at the tip by the side of a major diameter.

[0008] Namely, originally, although it is the joint member of the diameter of said, the first of this invention In order to cancel the high shearing stress generated in a junction interface and to give compressive residual stress to a junction interface The diameter of a member with a large coefficient of thermal expansion is made larger than the diameter of another member joined to this. (Making it preferably about 1.5 or more times) And it is that a joint is not flat, process a truncated-cone-like depression at the tip by the side of a major diameter, the tip by the side of another minor diameter prepares the heights of the same configuration as the above-mentioned depression, and

both formed the friction surface. Although the diameter of said is also possible for this configuration, since the heat capacity of the periphery of a member which has the depression section is small, it is overheated previously, it softens and joining becomes inadequate, the diameter of a member with the large coefficient of thermal expansion which has the depression section is enlarged.

[0009] Moreover, the second of this invention establishes the slot of a wedge or a hemicycle in the slant face (inclination part) of a truncated-cone-like depression, by friction welding, the above-mentioned slot is made to consume another member, a pressure welding is completed, and it makes it possible to increase bonding strength according to the so-called anchor effect. As for each junction interface, compressive stress remains.

[0010]

[Function] processing truncated-cone-like a crevice and heights at the tip of the member which should be joined, respectively, making this section generate heat by friction, carrying out upsetting pressurization from shaft orientations, and making a truncated-cone-like junction interface constitute -- moreover, by establishing a truncated-cone-like crevice in the member with a large coefficient of thermal expansion among both members, the load of the compressive stress is carried out to the slant face of a plane of composition by the cooling process after friction welding, and bonding strength increases. Furthermore, since it has a large plane of composition, bonding strength can be made to increase from the conventional flat joint side in proportion to the increment of area.

[0011] On the other hand, increase and the so-called anchor effect of a plane-of-composition product are further expectable by processing the slot of the shape of a wedge or a semicircle on the slant face of a truncated-cone-like crevice. Thus, according to this invention, manufacture of the components which the friction welding of the transition joint made quite difficult becomes possible, and have a reliable joint can be performed.

[0012] That is, this invention is having considered as the joint structure of using a different material property positively and utilizing the residual stress to generate for increase of joint reinforcement, and the most serves as compressive stress of a junction interface, and it is made for the shearing stress of the junction interface generated with the conventional method to act effectively to joint reinforcement in this invention.

[0013]

[Example] Drawing 1 explains one example of this invention, and the description and effectiveness of this invention are clarified. In drawing 1, Members A and B are

ingredients different, respectively, and explain SUS material and Ti alloy as an example. In SUS304 material and Ti-6aluminum - 4V material, since the coefficient of thermal expansion is [ the SUS304 material ] larger compared with Ti-6aluminum - 4V material, in A material, SUS304 and B material serve as Ti-6aluminum - 4V alloy. in this case, the relation between the diameter (DA) of A material, and the diameter (DB) of B material --  $DA \geq 1.5DB$  -- carrying out is desirable. It is DA which is made such relation. If it enlarges not much, an ingredient will become useless, and it is DA. It is because it will be overheated previously, the outside of A material will soften, upsetting pressurization will stop acting effectively and joining will be easy to become inadequate, if it is made small. Therefore, in order to lessen futility of an ingredient and to obtain high bonding strength, it is  $DA = 1.5DB$ . It is the most suitable. On the other hand, processing will become difficult, if the depth (dA) of a depression is also not much deep and it carries out. Therefore, they are  $dA = 1/2DB$  in practice. It can be said that extent is the most suitable.

[0014] It shows other examples of this invention, and further, drawing 2 forms the slot 1 of the shape of a wedge shape or a semicircle, and the plane of composition shown at drawing 3 according to the upsetting force of generation of heat by friction and shaft orientations is formed, and it adds the wedge effectiveness to the compressive stress by which a load is carried out at a plane of composition in the inclined plane of the depression of the shape of a truncated cone processed into A material. In addition, two show the weld flash of B material among drawing 3 .

[0015] Drawing 4 was what showed the radial stress distribution of the friction welding section checked according to the example of this invention, the stress is remarkably high and the reliable joint was obtained as compressive stress remained in the junction interface altogether, especially it went outside.

[0016] Drawing 5 is a microphotography (one 5 times the scale factor of this) in which the metal texture of the pressure-welding cross section just behind friction welding is shown, and it turns out that the contaminant has joined completely by the friction welding method of this invention. According to the example of this invention, the reinforcement of a joint (joint) was more than base material reinforcement.

[0017]

[Effect of the Invention] It not only made possible conventionally friction welding of the contaminant by which junction was made very difficult, but according to this invention, it can obtain high joint reinforcement.

[Brief Description of the Drawings]

[Drawing 1] The explanatory view of one example of this invention.

[Drawing 2] The explanatory view of other examples of this invention.

[Drawing 3] The explanatory view of the joint by the example shown in drawing 2 .

[Drawing 4] The graph showing the stress distribution which remains to the transition joint of this invention.

[Drawing 5] The microphotography in which the metal texture of an example of the joint joined by the approach of this invention is shown.

[Drawing 6] The conventional friction conjugation method is an explanatory view [ like ] 1 voice.

[Drawing 7] The explanatory view of the longitudinal direction of the joint obtained by the conventional friction conjugation method.

[Drawing 8] The graph showing the stress distribution which remains to the transition joint obtained by the conventional friction conjugation method.

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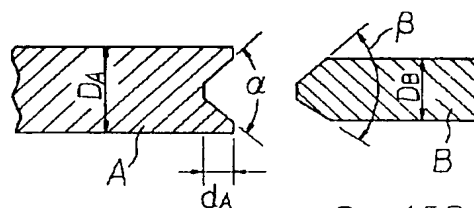
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(54)【発明の名称】 異材の摩擦圧接法

(57)【要約】

【目的】 異材の摩擦圧接法に関する。

【構成】 ①熱膨張係数や高温強度などの材料特性の異なる異材を摩擦圧接させるに際し、熱膨張係数の大きな材料の直径を、これと接合する他の材料の直径よりも大きくし、かつ大径側の先端に円錐形の凹みを設け、小径側の先端には上記凹みと同一形状の凸部を設けておき、両材料を摩擦圧接させて異材を摩擦圧接する方法及び②上記①の方法において大径側の先端の円錐形の凹みの斜面に溝を設けて異材を摩擦圧接する方法。



$$D_A \geq 1.5 D_B \quad \alpha = \beta$$

$$d_A \geq 1/2 D_B$$

## 【特許請求の範囲】

【請求項1】 熱膨張係数や高温強度などの材料特性の異なる異材を摩擦圧接させるに際し、熱膨張係数の大きな材料の直径を、これと接合する他の材料の直径よりも大きくし、かつ大径側の先端に円錐形の凹みを設け、小径側の先端には上記凹みと同一形状の凸部を設けておき、両材料を摩擦圧接させることを特徴とする異材の摩擦圧接法。

【請求項2】 大径側の先端の円錐形の凹みの斜面に溝を設けてなることを特徴とする請求項1記載の異材の摩擦圧接法。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】本発明は異材の摩擦圧接法に関し、各種の異材継手部品、特に科学衛星などに搭載される燃料タンクの配管などに適用される異材継手部品の製造に適する同方法に関する。

## 【0002】

【従来の技術】従来、棒状又は管状の異材継手の摩擦圧接は図6に示す如く、材料特性の異なる同径の異材(A、B)を、圧接装置のチャックで掴み、一方を回転させて接合すべき部分を摩擦エネルギーで加熱し、軸方向の加圧力(P)によりアプセット加圧して行っていた。したがって、接合後の軸方向断面は図7に示す如く、同径のA材とB材が接合され、それぞれの材料強度に応じてバリの量と形状が異なった状況を呈する。従来の、このような継手において最も問題となるのが、両部材(A、B)の材料特性の差異によって生じる残留応力の発生と、これに伴う継手強度の低下である。

【0003】すなわち、異材は特に、熱膨張係数や高温強度が大幅に異なる場合が多く、このような場合、従来の方法で単純に摩擦圧接を行うと、両者の接合界面には図8に示すような残留応力(剪断応力)( $\tau$ )が発生する。図8は、座標軸の原点を接合界面の軸心におき、部材の半径方向に対する剪断応力( $\tau$ )の分布を示したもので、剪断応力( $\tau$ )は部材の表面で2次函数的に増大し、これが圧接後の割れ発生や、割れ発生がない場合でも継手強度の低下などの原因になる。

## 【0004】

【発明が解決しようとする課題】前項で明らかにしたように、材料特性の異なる異材を同径のままで、接合面が平坦の状態では摩擦圧接を行うと、接合界面を破壊しようとする高い応力が発生し、割れ発生や継手強度の低下をまねくことになり、信頼性の高い継手材が得られないという欠点があった。

【0005】本発明は上記技術水準に鑑み、従来法の欠点を解消して、信頼性の高い継手材を得ることができる異材の摩擦圧接法を提供しようとするものである。

## 【0006】

【課題を解決するための手段】本発明は

(1) 熱膨張係数や高温強度などの材料特性の異なる異材を摩擦圧接させるに際し、熱膨張係数の大きな材料の直径を、これと接合する他の材料の直径よりも大きくし、かつ大径側の先端に円錐形の凹みを設け、小径側の先端には上記凹みと同一形状の凸部を設けておき、両材料を摩擦圧接させることを特徴とする異材の摩擦圧接法、

【0007】(2) 大径側の先端の円錐形の凹みの斜面に溝を設けてなることを特徴とする上記(1)記載の異材の摩擦圧接法である。

【0008】すなわち、本発明の第一は本来、同径の継手部材であるが、接合界面に発生する高い剪断応力を解消し、接合界面へ圧縮の残留応力を与えるために、熱膨張係数の大きい部材の直径を、これと接合する別の部材の直径よりも大きくし、(好ましくは約1.5倍以上にし、)かつ、接合部は平坦ではなく、大径側の先端には円錐台状の凹みを加工し、別の小径側の先端は上記凹みと同一形状の凸部を設け、両者が摩擦面を形成するようにしたことである。この形状は同径でも可能であるが、凹み部を有する部材の外周の熱容量が小さいため、先に過熱されて軟化し、接合不十分となるので、凹み部を有する熱膨張係数の大きい部材の直径の方を大きくしたものである。

【0009】又、本発明の第二は円錐台状の凹みの斜面(傾斜部分)に楔形又は半円形の溝を設け、摩擦圧接によって別の部材を、上記溝に喰い込ませて、圧接を完了し、いわゆるアンカー効果によって接合強度を増大させることを可能にしたものである。接合界面はいずれも圧縮応力が残存する。

## 【0010】

【作用】円錐台状の凹部と凸部をそれぞれ、接合すべき部材の先端に加工し、該部を摩擦発熱させて、軸方向からアプセット加圧して、円錐台状の接合界面を構成させることによって、又、両部材のうち、熱膨張係数の大きい部材に円錐台状の凹部を設けることによって、摩擦圧接後の冷却過程で接合面の斜面には圧縮応力が負荷され、接合強度が増加する。さらに、従来の平坦な継手面より、広い接合面を有するので、面積の増加分に比例して接合強度を増加させることができる。

【0011】一方、円錐台状の凹部の斜面に、楔形や半円状の溝を加工することによって、更に接合面積の増大といわゆるアンカー効果が期待できる。このように、本発明によればかなり困難とされている異材継手の摩擦圧接が可能になり、かつ信頼性の高い継手を有する部品の製造ができる。

【0012】すなわち、本発明は異なる材料特性を積極的に利用し、発生する残留応力を、継手強度の増大のために活用する継手構造としたことであり、従来法で発生していた接合界面の剪断応力は本発明では、そのほとんどが接合界面の圧縮応力となり継手強度に対して有効に

作用するようにしたものである。

### 【0013】

【実施例】本発明の一実施例を図1によって説明し、本発明の特徴と効果を明らかにする。図1において、部材A及びBはそれぞれ異なった材料で、例としてSUS材とTi合金について説明する。SUS304材とTi-6Al-4V材ではSUS304材の方がTi-6Al-4V材に比べ、熱膨張係数が大きいので、A材はSUS304、B材はTi-6Al-4V合金となる。この場合、A材の直径( $D_A$ )とB材の直径( $D_B$ )の関係は $D_A \geq 1.5 D_B$ とすることが望ましい。このような関係にするのは $D_A$ を余り大きくすると材料が無駄となり、 $D_A$ を小さくすると、A材の外側が先に過熱されて軟化し、アプセット加圧が有効に作用しなくなり接合不十分となりやすいからである。したがって、材料の無駄を少なくし高い接合強度を得るためには $D_A = 1.5 D_B$ が最も適当である。一方、凹みの深さ( $d_A$ )も余り深くすると加工が困難となる。したがって、実際的には $d_A = 1/2 D_B$ 程度が最も適当と言える。

【0014】図2は本発明の他の実施例を示すもので、A材に加工された円錐台状の凹みの傾斜面に、更に、楔状又は半円状の溝1を設け、摩擦による発熱と軸方向のアプセット力によって図3に示す接合面を形成し、接合面に負荷される圧縮応力に楔効果をプラスしたものである。なお、図3中、2はB材のバリを示す。

【0015】図4は本発明の実施例によって確認された\*

\* 摩擦圧接部の半径方向の応力分布を示したもので、接合界面には全て圧縮応力が残り、特に外側へいくにつれてその応力は著しく高くなっており、信頼性の高い継手が得られた。

【0016】図5は摩擦圧接直後の圧接断面の金属組織を示す顕微鏡写真(倍率5倍)であり、本発明の摩擦圧接法により異材が完全に接合していることが判る。本発明の実施例によれば継手(接合部)の強度は母材強度以上であった。

### 【0017】

【発明の効果】本発明によれば、従来、接合が極めて困難とされていた異材の摩擦圧接を可能にしたばかりでなく、高い継手強度を得ることができる。

### 【図面の簡単な説明】

【図1】本発明の一実施例の説明図。

【図2】本発明の他の実施例の説明図。

【図3】図2に示した実施例による接合部の説明図。

【図4】本発明の異材継手に残留する応力分布を示す図表。

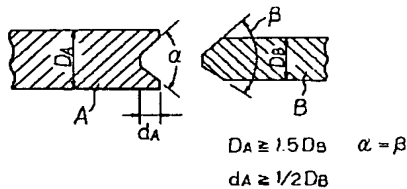
【図5】本発明の方法によって接合した接合部の一例の金属組織を示す顕微鏡写真。

【図6】従来の摩擦接合法の一態様の説明図。

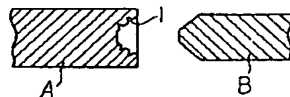
【図7】従来の摩擦接合法によって得られた継手の長手方向の説明図。

【図8】従来の摩擦接合法によって得られた異材継手に残留する応力分布を示す図表。

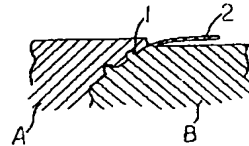
【図1】



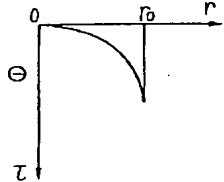
【図2】



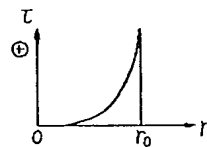
【図3】



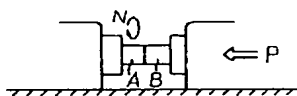
【図4】



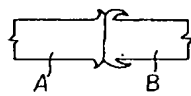
【図8】



【図6】



【図7】



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【図5】

